RESPONSE OF BRICK MASONRY UNDER CYCLIC LOADING

by

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CERTIFICATE

This is to certify that the thesis entitled "Response of Brick Masonry Under Cyclic Loading" being submitted by Milad Mahmud Shibani to the Indian Institute of Technology, Delhi for the award of the Degree of Philosophy in Civil Engineering, is a record of bonafide research work carried out by him. Mr. Milad M. Shibani has worked under my guidance and supervision and has fulfilled the requirements for the submission of this thesis, which to my knowledge, has reached the requisite standard.

This thesis, or any part thereof; has not been submitted to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

This thesis presents an experimental investigation of sand plast brick masonry under cyclic loading. Three loading regimes were employed for the study; uniaxial cyclic compression and tension, biaxial cyclic compression - compression, and biaxial cyclic compression - tension.

The first phase of the study was to conduct a uniaxial cyclic test in the compression and tension states. A square panel made up of half-scale bricks was used for this study. Two cases of loading was considered: load normal to the bed joint and load parallel to the bed joint. Due to low strength of plain masonry in tension, no useful information could be derived from the cyclic tensile test. For the cyclic test under compression, three types of test were conducted for each loading case: (i) Monotonic test, (ii) Cyclic test consisting of loading-unloading, in which peak of each loading cycle approximately coincided with the monotonic curve. The stress strain hysteresis of this test possess a locus of common points, (iii) Cyclic test consisting of repeated loading-unloading several times, where each time the load was released when the reloading curve intersects the initial unloading curve, until the points of intersection stabilises at a lower bound point. The locus of these lower bound points is termed as the stability points.

Mathematical expressions were proposed for the envelope, common point and stability point curves, Mathematical models were also presented to obtain loading-unloading curves at any given plastic strain. Stiffness degradation and strength deterioration due to cyclic loading were presented and it was quantified by mathematical expressions with respect to envelope strain, plastic strain, energy dissipation and load level, A pivot point model to reproduce the stress -

strain hysteresis was presented. The model utilises focal (pivot) points in the uniaxial stress strain plane that are derived based on geometrical properties of the cyclic stress - strain curves.

The effect of panel aspect ratio on the cyclic behaviour of brick masonry loaded parallel to the bed joint was experimentally investigated. For the range of aspect ratios considered, it was concluded that the change in aspect ratio has marginal effect on its cyclic behaviour.

Experimental study on the behaviour of the brick masonry due to partial unloading was carried out for two unloading stress levels. Common points and residual strains due to partial unloading were mathematically expressed.

Cyclic tests were conducted on brick masonry panels under biaxial compression - compression normal and parallel to the bed joint. A range of five principal stress ratios were considered. For each principal stress ratio, the stress - strain hysteresis, the envelope curve, the locus of common points, the locus of stability points and the plastic deformation curves were determined.

Analytical curves similar to those for uniaxial cyclic compressive behaviour were used to define the envelope, the common point and the stability point curves. A failure interaction curve in the compression - compression stress state region was proposed based on stress invariants. A generalised approach was presented to obtain the envelope, the common point and the stability point curves.

Cyclic tests were also conducted on brick masonry panels under biaxial compression - tension. A range of four principal stress ratios were considered. The compressive force was applied normal to the bed joint and for tensile force was applied parallel to the bed joint. The envelope curve and the locus of common points could be established for only two principal stress ratios. Mathematical expressions were proposed for envelope and common point curves. A failure interaction curve for biaxial compression - tension stress state region was proposed.

Specimens which failed in compression - tension can further sustain uniaxial compressive loading. Therefore, a post failure behaviour of brick masonry which failed under biaxial compression - tension was experimentally investigated. The damaged panels were subjected to uniaxial cyclic compression and post failure envelope, common point and stability point curves were established. The three curves were found to follow similar behaviour as those under uniaxial cyclic compression.

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